TITLE OF THE INVENTION

PATTERN FORMING MEMBER APPLIED TO SECTIONING IMAGE OBSERVATION APPARATUS AND SECTIONING IMAGE OBSERVATION APPARATUS USING THEM

CROSS-REFERENCE TO RELATED APPLICATIONS

This is a Continuation Application of PCT Application No. PCT/JP01/01710, filed March 6, 2001, which was not published under PCT Article 21(2) in English.

This application is based upon and claims the benefit of priority from the prior Japanese Patent Application No. 2000-060578, filed March 6, 2000, the entire contents of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a pattern formation member applied to a sectioning image observation apparatus for observing/measuring sample microstructure or three-dimensional shape of a sample by using light and a sectioning image observation apparatus using them.

2. Description of the Related Art

Conventionally, as a sectioning image observation apparatus, a confocal microscope using a rotation disk called Nipkow rotation disk where a number of pin holes are arranged in spiral with an interval of about

ten times of the pin hole diameter is known.

FIG. 1 shows the schematic configuration of a confocal microscope using such a Nipkow rotation disk, wherein a condenser lens 2 and a PBS (polarized beam splitter) 3 are arranged on a light path of the light emitted from a light source 1 such as halogen light source or mercury light source or others, and a Nipkow rotation disk (called rotation disk, hereinafter) 4, a first imaging lens 5, 1/4 wavelength plate 6 and a sample 8 through an objective 7 are arranged on the reflected light path of the PBS 3. In addition, a CCD camera 10 is arranged through a second imaging lens 9 on the filtered light path of the PBS 3 of the light reflected from the sample 8. A monitor 11 is connected to the image output terminal of this CCD camera 10 for displaying the image taken by the CCD camera.

Here, pin holes 4a are arranged in spiral on the rotation disk 4 with an interval of about ten times of the pin hole diameter between respective pin holes, and the rotation disk 4a is connected to the shaft of a not shown motor via a rotation shaft 12 and rotated at a fixed rotation speed.

In such configuration, the light emitted from the light source 1 passes through the condenser lens 2 and only polarized component of a fixed direction is reflected by the PBS 3 and input to the rotation disk 4 rotating at the fixed speed, and the light filtered by

the pin hole 4a of this rotation disk 4 passes through

the first imaging lens 5, circularly polarized by the

1/4 wavelength plate 6, imaged by the objective lens 7

and input to the sample 8. On the other hand, the

5   light reflected from the sample 8 passes through the

objective lens 7, takes a polarization direction

orthogonal to the incident light again at the 1/4

wavelength plate 6, and projects the sample image on

the rotation disk 4 by means of the first imaging

10   lens 5. A focused portion of the sample image

projected on the rotation disk 4 passes through the pin

hole 4a, further passes through the PBS 3 and taken by

the CCD camera 10 through the second imaging lens 9.

A confocal image taken by the CCD camera 10 is

15   displayed on the monitor 11.

Such confocal microscope allows to observe a

so-called sectioning image, namely image for each level

of the sample 8, by moving the focus vertically (Z axis

direction), as only images having focused position

20   (height) where the pin hole 4a of the rotation disk 4

passes can be observed.

By the way, for the confocal microscope using

such Nipkow rotation disk, it is necessary to dispose

pin holes on the rotation disk so that unevenness may

25   not come into prominence in the observation field

during the eye observation or imaging by a CCD camera.

In short, it is necessary to arrange pin holes so that

the sample observation field is illuminated evenly within a human perceptible time interval (about 1/20 to 1/30 sec) or CCD camera exposure time (often 1/60 or 1/30 sec).

5   Therefore, conventionally, various proposals have been made concerning the pin hole arrangement and, for instance, an arrangement wherein a plurality of pin holes are arranged in spiral in the rotation disk radial direction with an equal angle is known as the

10   simplest arrangement. However, in such pin hole arrangement, the brightness of captured image is uneven, because the pin hole pitch is different in the outer circumferential section and the inner circumferential section of the rotation disk.

15   As a method to solve such problem, various pin hole arrangements for reducing the uneven brightness of captured image, such as an arrangement wherein the radial pitch of the locus of the virtual center line connecting centers of a plurality of pin holes

20   composing pin hole lines arranged in spiral and the circumferential pitch along the spiral are made equal, or an arrangement wherein all pin holes composing a plurality of pin hole lines are differentiated in diameter at their center position have been proposed.

25   However, in the former pin hole arrangement, certainly, the image brightness in the observation field is even when the rotation disk center and the

rotation axis agree exactly, but the observed image brightness is uneven when the rotation disk center and the rotation axis disagree. In general, the pin hole diameter is so small as about several dozens of μm

5 (45 μm for 100 times, 100 μm for 250 times); therefore, it is necessary to limit the difference between the rotation disk center and the rotation center to 10 μm or less, namely sufficiently smaller than the pin hole diameter so that the observed image

10 brightness may not be uneven, thereby, requiring an extremely high precision for perforation of pin hole on the rotation disk, shaping of the rotation disk, attachment of the rotation disk to the rotation shaft, or other processing.

15   On the other hand, the latter pin hole arrangement is improved to reduce the unevenness of observed image brightness; however, the unevenness is certainly reduced, but not eliminated.

     In addition, when pin holes are formed on the

20 rotation disk in this way, the pin hole arrangement is so devised not to make the observed image brightness uneven for all samples, and the pin hole is positioned using a complicated pattern prepared extremely precisely, in order to position each pin hole exactly.

25 For instance, for Nipkow rotation disk, Cr or low-reflective Cr film is formed on a glass substrate, masked with a pin hole pattern and etched, and this

mask is prepared by a EB drawing machine using electron beam similarly as semiconductor manufacturing, making the rotation disk preparation very costly and expensive due to the use of such complicated pattern mask.

5   Therefore, in order to solve these problems, it has been proposed a rotation disk wherein a straight line pattern section 141 including linearly formed translucent sections and shield sections arranged alternately, a full translucent section 142, and shield
10   sections 143, 144 in each fan-shaped areas between these straight line pattern section 141 and full translucent section 142 are disposed on a rotation disk 14 as shown in FIG. 3A, and the width of translucent sections and shield sections of the straight line
15   pattern section 141 among them is set to about several dozens of μm similarly as the pin hole diameter, and formed to 1:1 as shown in FIG. 3A and FIG. 3B.

According to such rotation disk, first, an observation when the observation field passes through
20   the straight line pattern section 141 is taken by the CCD camera, then an observation when it passes through the full translucent section 142 is taken by the CCD camera. In this case, a combined image (confocal image including non-confocal component) including not only
25   an image having focused position (height) components (confocal component), but also image having non-focused position (height) components (permeated non-confocal

component) is obtained, because the ratio of each width
of translucent sections 141a and shield sections 141b
is equal, for the image taken in the straight line
pattern section 141. Consequently, only the confocal

5   image having position (height) components in good focus
ban be obtained by the difference calculation of
bright-field taken through the full translucent section
142 from this combined image. In addition, uneven
brightness is not generated in the observation image

10   even when the rotation disk rotation center has
shifted, and the rotation disk preparation cost will be
limited because the pattern for creating the straight
line pattern section 141 including linearly formed
translucent sections and shield sections arranged

15   alternately is a simple linearly pattern.

On the contrary, in the rotation disk 141 shown
in FIG. 3A and FIG. 3B, the non-confocal component
is prominent, because the ratio of each width of
translucent sections and shield sections of the

20   straight line pattern section 141 is 1:1. Therefore,
a so-called sectioning effect, containing only
confocal image can be expected only by the difference
calculation. This generates problems such as
impossibility of directly viewing the confocal image,

25   necessity of operation equipment such as computer for
image processing, enlargement of equipment scale, cost
increase, and moreover, two images subjected to the

difference calculation are susceptible to disturbance such as vibration, because they are taken with different timing.

BRIEF SUMMARY OF THE INVENTION

An object of the present invention is to provide a pattern formation member applied to a sectioning image observation apparatus for stably observing a good image, without making the observed image brightness uneven and a sectioning image observation apparatus.

A pattern formation member adopted to a sectioning image observation apparatus which selectively irradiates a light from a light source to a sample, scans the sample, and acquires a light from the sample as a sectioning image, is characterized in that the pattern formation member comprises an irradiation section and a cutoff section, each of the irradiation section and the cutoff section is in a straight pattern, and these straight patterns are disposed alternatively.

Another pattern formation member adopted to a sectioning image observation apparatus which has a rotation disk having a translucent section which passes a light and a shield section which shields a light and rotating on a light path, irradiates a light passing through the translucent section to a sample, scans the sample, and passes a light from the sample passed through the rotation disk to acquire a sectioning

image, is characterized in that each of patterns to
scan the sample by the light passing through the
rotation disk is formed in a straight pattern, and
these patterns are disposed alternatively, straight

5   pattern areas of the translucent section and the shield
section with different direction are formed not to
be parallel to a scanning direction (H direction)
according to a rotation of the rotation disk in
an observation field.

10   Preferable manners of the present invention are as
follows.

(1)   The pattern formation member is a rotation
disk such that the irradiation section is a translucent
section to pass a light and the cutoff section is

15   a shield section to shield a light, the rotation disk
is rotated on a light path, each of patterns to scan
the sample by the light passing through the rotation
disk is formed in a straight pattern, and these
patterns are disposed alternatively.

20   (2)   A shield area is formed at a portion to
which straight patterns of the translucent section and
the shield section of the rotation disk is parallel
to a scanning direction (H direction) according to a
rotation of the rotation disk in an observation field.

25   (3)   The straight pattern areas have a plurality
of sector shaped areas divided in a circumferential
direction of the rotation disk.

(4) A portion parallel to a scanning direction (H direction) according to a rotation of the rotation disk in an observation field has another straight pattern area of the translucent section and the shield section with sector shape having a predetermined central angel whose direction differs from the straight pattern.

(5) A width of the straight pattern of the shield section is larger than that of the translucent section.

(6) The pattern formation member is a digital micro mirror having a plurality of mirrors, whose directions are independently changeable, disposed in a two-dimensional form.

(7) A plurality of areas having different ratios of the translucent section and the shield section are further provided.

(8) A plurality of areas having different direction of the translucent section and the shield section of the straight pattern of the rotation disk are further provided.

(9) The rotation disk is a rotation disk in which a rotation radial direction of the rotation disk is not normal to a direction of the straight pattern of the translucent section and shield section.

(10) A width of a straight portion of the rotation disk which shield a light is larger than a width of a straight portion thereof which passes

a light.

(11) A width of a straight portion of the rotation disk is substantially constant.

(12) The rotation disk is divided into a plurality of areas and a pattern of each of the plurality of areas is different.

(13) A pattern of each of the plurality of areas has an equal area ratio of the translucent section and the shield section, and widths of the translucent section and the shield section are different for each of the areas.

(14) When a width of different direction area having a constant width is X and a period of the translucent section and the shield section is W in the rotation disk, X/W is constant.

(15) The patterns of the plurality of concentric circle areas have an equal area ratio of the translucent section and the shield section, a width of inner circumference concentric circle area is smaller than that of outer circumference concentric circle area, and a width of different direction area of the inner circumference concentric circle area is smaller than that of outer circumference concentric circle area.

(16) When the translucent sections of the least two concentric circle areas have a same width and a period W of the translucent section and the shield

section is different, a period of the translucent
section and the shield section on an inner concentric
circle area is smaller than that of an outer concentric
circle area, and a width X of a different direction

5   area of inner and outer concentric circle areas is
proportional to the period W.

A sectioning image observation apparatus according
to the present invention scans a sample with a light
by using any one of above-mentioned pattern formation

10   members, and acquires a reflected light from the sample
as a sectioning image through the pattern formation
member. With this arrangement, it is preferable that
a moving mechanism to change a projection position on
the rotation disk to the sample is further provided.

15   Another sectioning image observation apparatus
according to the present invention enters an excited
light with a predetermined wavelength through an
excitation filter to any one of above-mentioned pattern
formation members, scans a sample with a light by

20   using the pattern formation member, and acquires a
fluorescence emitted from the sample as a sectioning
image through the pattern formation member and a
barrier filter selecting a wavelength of the emitted
fluorescence.

25   A still another sectioning image observation
apparatus is characterized by comprising: a light
source; a rotation disk having a pattern in which

a slit translucent section which passes a light and a straight shading section which shields a light, are alternately and periodically arranged; means to lead a light from the light source to the rotation disk;

5   means to irradiate a light passing the rotation disk to a sample and project a pattern of the rotation disk to the sample; an optical lens which projects a light reflected from the sample on the rotation disk; and means to rotate the rotation disk on an optical path,

10   scan the pattern of the rotation disk projected on the sample, and acquires an image passing the rotation disk as an sectioning image among sample images projected on the rotation disk, and when an angle of the rotation disk surface and a surface normal to an optical axis is

15   θ, an aperture of the lens from the sample is NA, an expansion rate of a sample image projected on the rotation disk is M, a diameter (called as a number of view) on the rotation disk in an area of the observed sample is R, an angle between a main light beam which

20   passes at an outermost edge of a diameter on the rotation disk of the observed sample area and an optical axis is ϕ, and a wavelength of the light is λ, at least one of the following conditions are satisfied:

$\theta > \phi + 2NA/M$, and

25

$$\theta < \frac{M^2\lambda}{NA^2R}.$$

As the result, according to the present invention, a high quality observation image without uneven

brightness can be obtained even when the rotation disk rotation center has shifted, because the straight pattern of translucent sections and shield sections are scanned while changing the direction thereof according

5   to the rotation of the rotation disk 141.

Also, uneven brightness is prevented from occurring in the observed image, because it is so devised that the scanning direction (H direction) by the rotation of the rotation disk in the observation

10   field and the direction of the straight pattern of translucent sections and shield sections will not be parallel.

Moreover, the mask pattern preparation is simple and cheap in cost, because the straight patterns of

15   translucent sections and shield sections are only arranged alternately.

In addition, according to the present invention, the permeability of the rotation disk can be set by providing a plurality of areas where a pattern

20   constituted of alternately disposed straight translucent sections and shield sections, changing the line width for each area, and allowing to move the rotation disk use area, the sectioning effect and the image brightness can be set selectively according to

25   the sample situation, light can be used effectively according to the sample, and it becomes possible to obtain a bright sectioning image for various kinds of

samples.

Further, according to the present invention,
a pattern corresponding to the objective magnification
or number of apertures, among a plurality of patterns
on the disk, without making the observed image
brightness uneven, so a disk applied to a sectioning
image observation apparatus for stably observing a good
image, and a sectioning image observation apparatus can
be supplied.

Besides, according to the present invention,
a confocal image can be observed even with a plurality
of objectives, and images of different confocal effect
can be observed, by dividing a disk where translucent
sections and shield sections are arranged linearly into
a plurality of concentric areas, and changing the
translucent section slit width (L) and the shield
section width (W-L) in each area, and at the same time,
every confocal image observed in any area can be made
homogenous and satisfactory, because the width X of a
different direction area where patterns for suppressing
the generation of alternating contrast stripes can be
decided by the cycle W of translucent sections and
shield sections. Further, as the width of different
direction area can be decided easily, it is unnecessary
to remake times and times for deciding the width of
this area, reducing the examination time and the cost.

Moreover, according to the present invention,

the rotation disk inclination angle can be decided

practically for reducing unnecessary reflected light

(flare) by calculation considering the magnification of

the sample image projected on the disk, field of view

5   range, and light incident angle; therefore, not only

the angle can be decided to obtain a good contrast

sectioning image free of flare, but also it is possible

to include the disk inclination within the focal depth

of the sample, preventing an image focused to different

10   height on the sample from being observed.

Still further, according to the present invention,

in place of scanning the pattern where straight

translucent sections and shield sections are arranged

alternately using a disk, the pattern is created and

15   scanned by using a micro mirror array and changing the

direction of respective micro mirror. Consequently,

the slit light width can be created in correspondence

to various objectives, making useless to exchange

disks, or make a disk divided into a plurality of areas

20   circumferentially, and a quality confocal image can

be obtained simply, as a pattern corresponding to

an objective can be created, without modification.

Additional objects and advantages of the invention

will be set forth in the description which follows, and

25   in part will be obvious from the description, or may

be learned by practice of the invention. The objects

and advantages of the invention may be realized and

obtained by means of the instrumentalities and
combinations particularly pointed out hereinafter.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

The accompanying drawings, which are incorporated

5 in and constitute a part of the specification,
illustrate embodiments of the invention, and
together with the general description given above
and the detailed description of the embodiments
given below, serve to explain the principles of

10 the invention.

FIG. 1 shows a schematic configuration of
an example of a conventional confocal microscope;

FIG. 2 shows a schematic configuration of
a rotation disk used for the conventional confocal

15 microscope;

FIG. 3A and FIG. 3B show a schematic configuration
of a rotation disk used for the conventional confocal
microscope;

FIG. 4 shows a schematic configuration of a first

20 embodiment of the present invention;

FIG. 5A and FIG. 5B show a schematic configuration
of a rotation disk used for the first embodiment of the
present invention;

FIG. 6A and FIG. 6B illustrate the first

25 embodiment;

FIG. 7 shows a schematic configuration of
a rotation disk used for a second embodiment of

the present invention;

FIG. 8 shows a schematic configuration of a rotation disk used for a third embodiment of the present invention;

FIG. 9 shows a schematic configuration of a rotation disk used for a fourth embodiment of the present invention;

FIG. 10 shows a schematic configuration of a rotation disk used for a fifth embodiment of the present invention;

FIG. 11 is a figure to explain the fifth embodiment;

FIG. 12 shows a schematic configuration applied to the conventional confocal microscope of a sixth embodiment;

FIG. 13A and FIG. 13B show a rotation disk in the sixth embodiment of the present invention;

FIG. 14 shows a rotation disk in a seventh embodiment of the present invention;

FIG. 15A and FIG. 15B show a rotation disk in an eighth embodiment of the present invention;

FIG. 16 shows a rotation disk in a ninth embodiment of the present invention;

FIG. 17 shows a rotation disk in a tenth embodiment of the present invention;

FIG. 18 shows a rotation disk in an eleventh embodiment of the present invention;

FIG. 19 is a partial enlargement view of the pattern section of the rotation disk 28 in FIG. 18;

FIG. 20 illustrates a twelfth embodiment of the present invention;

FIG. 21 shows the relationship between the contrast ratio and the different direction area width X;

FIG. 22 shows the relationship between the contrast ratio and the different direction area width X;

FIG. 23A and FIG. 23B show a rotation disk in a thirteenth embodiment of the present invention;

FIG. 24 shows the calculation results of the relationship between the contrast ratio and the different direction area width X;

FIG. 25 shows the calculation results of the relationship between the contrast ratio and the different direction area width X;

FIG. 26 shows a rotation disk in a fourteenth embodiment of the present invention;

FIG. 27 is a partial enlargement view of the rotation disk and a first eyepiece;

FIG. 28 shows a rotation disk in a fifteenth embodiment of the present invention;

FIG. 29 shows a configuration of a sixteenth embodiment of the present invention;

FIG. 30A to FIG. 30C show a configuration of

a micro mirror array;

FIG. 31A and FIG. 31B show pattern examples created by the micro mirror array;

FIG. 32A to FIG. 32D show pattern examples created by the micro mirror array;

FIG. 33 shows a schematic configuration of a seventeenth embodiment of the present invention;

FIG. 34 shows the permeability of an excitation filter used in the seventeenth embodiment; and

FIG. 35A and FIG. 35B show the reflectivity/ permeability of PBS and absorbing filter used in the seventeenth embodiment.

DETAILED DESCRIPTION OF THE INVENTION

Now, embodiments of the present invention will be described referring to attached drawings.

(First embodiment)

FIG. 4 shows a schematic configuration of a confocal microscope having a confocal effect as sectioning image observation apparatus (called confocal microscope, hereinafter) to which the present invention is applied, and same symbols are affected to the parts identical to FIG. 1.

In this case, a condenser lens 2, a deflecting plate 15, and a PBS (polarized beam splitter) 3 are arranged on a light path of the light emitted from a light source 1 such as halogen light source, mercury light source or the like, and a rotation disk 13 which

is a pattern formation member, a first imaging lens 5,
1/4 wavelength plate 6 and a sample 8 through an
objective 7 are arranged on the reflected light path of
the PBS 3. In addition, a CCD camera 10 is arranged

5   through a second imaging lens 9 on the filtered light
path of the PBS 3 of the light reflected from the
sample 8. A monitor 11 is connected to the image
output terminal of this CCD camera 10 for displaying
the image taken by the CCD camera 10.

10   Here, the rotation disk 13 is connected to the
motor (not shown) to be able to transmit, that is,
the shaft of the motor via a rotation shaft 12 etc.
and rotated at a fixed rotation speed. As shown in
FIG. 5A, respective patterns of linearly formed

15   translucent sections 13a and linearly formed shield
sections 13b are arranged alternately on the rotation
disk 13.

In this case, as shown in FIG. 5A and FIG. 5B,
the width of the straight shield section 13b is larger

20   than the straight translucent section 13a and is set to
1:9 for example. Besides, suppose the projection
magnification of the sample image on the rotation disk
13 be M, light wavelength λ and the aperture of the
objective NA, the width L of the straight translucent

25   section 13a is decided by the following expression:

$$L = k \lambda M / NA \qquad \cdots \ (1)$$

Here, k represents a coefficient, and k = 0.5 to 1

or so is often used.

For instance, as the objective 7, if the magnification 100 times, NA = 0.9 are used, λ is visible and 550 nm is often used, and the width L becomes approximately 45 μm, but set within the range of 30 to 60 μm considering k = 0.5 to 1.

Next, the function of thus constituted first embodiment will be described.

Light emitted from the light source passes the condenser lens 2, becomes a straight line polarized light containing only a certain polarized light at the deflecting plate 15, and enters the PBS 3. The PBS 3 reflects the polarized light in the direction passing through the deflecting plate 15, and permeates the polarized light in a direction perpendicular thereto. Light reflected by the PBS 3 enters the rotation disk 13 rotating at a fixed speed.

Then the light having passed through the straight translucent section 13a of this rotation disk 13, passes through the first imaging lens 5, becomes a circular polarized light at the 1/4 wavelength plate 6, is imaged by the objective 7 and enters the sample 8. On the other hand, light reflected from the sample 8 passes through the objective 7, becomes a straight polarized light orthogonal to the incidence at the 1/4 wavelength plate 6, and forms a sample image on the rotation disk 13 through the first imaging lens 5.

Considering a moment during the observation of the sample 8, as show in FIG. 6A, line projection is performed in a certain direction. Then, in this sate, if the light reflected from the sample 8 forms an image on the rotation disk 13, a focused portion of the sample 8 can pass through the rotation disk 13 because it is projected in line by multiplying the line projected on the rotation disk 13 with the sample image, most of non-confocal image cannot pass through the rotation disk 13, because its image projected on the rotation disk 13 is also not focused. As it is, the sample image and the pattern image are simply superposed; however, according to the rotation of the rotation disk 13, the pattern image is shifted (scanned) on the sample image changing the direction, they are averaged to erase the line image and a focused quality image can be observed.

Accordingly, if the rotation disk 13 rotates fast enough in respect to the exposure time of the CCD camera 10, a confocal image take by the CCD camera 10 can be observed by the monitor 11. To be more specific, in this case, if the CCD camera 10 is an ordinary TV rate, the exposure time is 1/60 or 1/30 sec; therefore, it may be set to 1800 rpm with which the rotation disk 13 makes a half revolution during these exposure times.

Therefore, in this way, a sectioning image which

is a confocal image can be obtained by a simple pattern
configuration of arranging alternately patterns of
straight translucent sections 13a and shield sections
13b. In addition, a high quality observation image
without uneven brightness can be obtained even when
the rotation disk rotation center has shifted, because
straight line patterns of straight translucent sections
and shield sections are arranged, the straight lines
are always scanned in different directions according to
the rotation of the rotation disk, different from the
case of the aforementioned pin holes.

Besides, the mask pattern can be created by the
EB drawing machine at an extremely low cost, because
only straight patterns are arranged, different from
a complicated arrangement of a number of pin holes as
in the case of Nipkow rotation disk.

(Second Embodiment)

Now, the second embodiment of the present
invention will be described.

In this case, as the confocal microscope to which
the second embodiment is applied is similar to that in
FIG. 4, FIG. 4 will be used.

By the way, considering the pattern movement in
the observation field during the rotation of the
aforementioned rotation disk 13, as translucent
sections 13a and shield sections 13b are formed with
straight patterns, the scanning direction (H direction)

by the rotation of the rotation disk in the observation field and the straight line patterns of translucent sections 13a and shield sections 13b may become parallel as shown in FIG. 6B, before and after this,

5 the observation image may have an uneven brightness in the rotation direction of the rotation disk, because, in this state, the pattern projected on the sample varies hardly, even when the rotation disk 13 continues to rotate.

10 FIG. 7 shows a rotation disk considering the uneven brightness that had possibilities to appear in the observation image described using FIG. 6B, and now, a confocal microscope using the rotation disk shown in FIG. 7 will be described referring to FIG. 4.

15 In this case, for the rotation disk 13, respective straight patterns of linearly formed translucent sections 13a and straight shield sections 13b are arranged alternately all over the rotation disk surface, and among these straight patterns of

20 translucent sections 13a and shield sections 13b, fan-shaped shield areas 13c, 13d are formed with several degrees of center angle, along a direction orthogonal to the straight pattern of these translucent sections 13a and shield sections 13b, in the portion

25 parallel to the scanning direction (H direction) by the rotation direction of the rotation disk in the observation field.

Therefore, the shield areas 13c, 13d are formed in the portion where the scanning direction (H direction) by the rotation of the rotation disk in the observation field and the straight line patterns of translucent sections 13a and shield sections 13b may become parallel, in a way to inhibit to observe the image in this portion, thereby preventing an uneven brightness from appearing in the observed image.

Moreover, in the shield areas 13c, 13d on the rotation disk 13, the light from the light source 1 to the sample 8 is shielded, the brightness may vary among images taken successively, if the rotation of the rotation disk 13 is slow in respect to the exposure time of the CCD camera 10, and this problem can be resolved by synchronizing the rotation of the rotation disk 13 and the shooting by this CCD camera 10 so that, for instance, the rotation disk 13 makes a half revolution during the exposure time of the CCD camera 10.

(Third Embodiment)

Now, the third embodiment of the present invention will be described.

In this case, as the confocal microscope to which the third embodiment is applied is similar to that in FIG. 4, FIG. 4 will be used.

FIG. 8 shows a schematic configuration of a rotation disk used for such confocal microscope, and fan-shape areas 161, 162, 163 divided into three in the

circumferential direction are formed on the rotation
disk 16, as shown in FIG. 8, and patterns of straight
translucent sections 16a and straight shield sections
16b are arranged alternately in respective areas 161,

5   162, 163.   In this case, straight translucent sections
16a and shield sections 16b in respective areas 161,
162, 163 change the straight direction in the
observation field, according to the rotation of the
rotation disk 16, and at this time, it is set so that

10   the scanning direction (H direction) by the rotation of
the rotation disk in the observation field and the
straight line patterns of translucent sections 16a and
shield sections 16b never become parallel in any case.

       In addition, in this case, the width of the

15   straight shield section 16b is larger than the straight
translucent section 16a and is set to 1:9 for example.
Besides, the width L of the straight translucent
section 16a is decided by the expression (1) mentioned
above.

20   According to such rotation disk 16, considering
a moment during the observation of the sample 8,
similarly as described for FIG. 6A, the pattern of
the translucent sections 16 is line projected slant in
a certain direction.   Then, in this sate, the light

25   reflected from the sample 8 forms an image on the
rotation disk 16, a focused portion of the sample 8 is
projected in line on the rotation disk 16, however,

most of non-confocal image cannot pass through the rotation disk 16, because its image projected on the rotation disk 16 is also not focused, and only confocal image passes through the rotation disk 16. As it is, the sample image and the pattern image are simply superposed; however, according to the rotation of the rotation disk 16, the pattern image moves on the sample image changing the direction.

In this case also, when the scanning direction (H direction) by the rotation of the rotation disk in the observation field and the straight line patterns of translucent sections 16a and shield sections 16b become parallel as shown in FIG. 6B as mentioned above, the observation image may have an uneven brightness, because, in this state, the pattern projected on the sample 8 varies hardly, even when the rotation disk 16 continues to rotate; however, according to the rotation disk 16 of this embodiment, as it is set so that the scanning direction (H direction) by the rotation of the rotation disk in the observation field and the straight line patterns of translucent sections 16a and shield sections 16b never become parallel in any case, an uneven brightness does not appear in the observed image, and moreover, the line-shape images are averaged by the rotation of the rotation disk 16, allowing to observe a focused quality image.

Consequently, in this way, the portion to be

parallel to the scanning direction (H direction) by the rotation of the rotation disk in the observation field is eliminated by forming a plurality of areas 161, 162, 163 different in direction with straight line patterns arranging translucent sections 16a and shield sections 16b alternately, an uneven brightness does not appear in the observed image, allowing to observe a focused quality image. In addition, as there is no portion shielding a quantity of light on the surface of the rotation disk 16, light can be used effectively, and further, a quality image can be obtained with less uneven brightness from the vicinity of the center of the rotation disk 16 to far way, by making the area width constant. Besides, the mask pattern can be created by the EB drawing machine, by scanning with electron beam in one direction, at an extremely low cost, because only straight patterns are arranged, different from a complicated arrangement of a number of pin holes as in the case of Nipkow rotation disk.

(Fourth Embodiment)

Now, the fourth embodiment of the present invention will be described.

In this case, as the confocal microscope to which the fourth embodiment is applied is similar to that in FIG. 4, FIG. 4 will be used.

FIG. 9 shows a schematic configuration of a rotation disk 17 used for such confocal microscope,

and patterns of straight translucent sections 16a and
straight shield sections 16b are arranged alternately
on the rotation disk 17 similarly as mentioned for
FIG. 5A and FIG. 5B. In addition, the relationship of

5   width of these translucent sections 17a and shield
sections 17b and the setting conditions of the width L
of the translucent section 17a are also as mentioned
for FIG. 5A and FIG. 5B.

Among the straight patterns of these straight

10   translucent sections 17a and straight shield sections
17b, areas 19a, 19 b having a plurality of translucent
sections 18a and shield sections 18b in a direction
orthogonal to the straight pattern of these translucent
sections 17a and shield sections 17b, are disposed

15   in the portion parallel to the scanning direction
(H direction) by the rotation direction of the rotation
disk in the observation field. In this case, the
areas 19a, 19 b are formed in fan-shape by changing
sequentially the length of respective straight patterns

20   from the rotation disk periphery, and the center angle
θ is decided by the reduction degree of uneven
brightness, width of the translucent sections 18a and
shield sections 18b, and distance R between the
observation field and the rotation disk 17 rotation

25   center. For instance, when the width of the
translucent sections 18a is 20 μm, width of shield
sections 18b 180 μm, and distance R 30 mm, in order to

reduce the uneven brightness to 1% or less, θ is set
to about 10 degrees.

Therefore, the use of such rotation disk 17 also
allows to obtain a sectioning image without uneven

5   brightness, and moreover, patterns can be formed easily
on the rotation disk 17, thereby reducing the cost,
because respective straight patters exist substantially
only in two directions as for the straight line
direction, even though divided in four areas.

10   (Fifth Embodiment)

Now, the fifth embodiment of the present invention
will be described.

In this case, as the confocal microscope to which
the fifth embodiment is applied is similar to that in

15   FIG. 4, FIG. 4 will be used.

FIG. 10 shows a schematic configuration of
a rotation disk 20 used for such confocal microscope,
and patterns of straight translucent sections 20a and
straight shield sections 20b are arranged alternately

20   on the rotation disk 20 similarly as mentioned for
FIG. 5A and FIG. 5B. In addition, the relationship of
width of these translucent sections 20a and shield
sections 20b and the setting conditions of the width L
of the translucent section 20a are also as mentioned

25   for FIG. 5A and FIG. 5B.

Among the straight patterns of these straight
translucent sections 20a and straight shield sections

20b, an area 22 of a fixed width X having a plurality

of translucent sections 21a and shield sections 21b in

a direction orthogonal to the straight pattern of these

translucent sections 20a and shield sections 20b, is

5 disposed in the portion parallel to the scanning

direction (H direction) by the rotation direction of

the rotation disk in the observation field.

In this case, the width X of the area 22 is

decided by the reduction degree of uneven brightness,

10 and width of the translucent sections 21a and shield

sections 21b. For instance, when the width of the

translucent sections 21a is 6 μm, and width of shield

sections 21b 54 μm, in the case of the rotation disk

17 mentioned for the fourth embodiment, the angle θ

15 for reducing the uneven brightness to a fixed value or

less in the portion near and in the portion far from

the rotation disk center, is different. In short,

suppose the distance from the rotation disk center be

R, the calculation of the angle θ for reducing the

20 uneven brightness to 1% or less, gives the result shown

in FIG. 11.

This result shows that the distance R is larger,

θ for reducing the uneven brightness to 1% or less

is smaller; however, when the observation field is

25 extremely large, as the portion near and the portion

far from the rotation disk center are equally used,

there will be prominent unevenness and attenuated

unevenness in the observation field, if the areas 19a, 19b are decided to make θ constant.

However, in case of the rotations disk 20 of this fifth embodiment, width X becomes a almost constant value as shown in FIG. 11 given X = R sinθ, the uneven brightness can be reduced to a fixed value or less all over the field even when the observation field is extremely large, allowing to observe the sample still better.

(Sixth Embodiment)

Now, the sixth embodiment of the present invention will be described.

The following problems may be indicated, in the first to fifth embodiments.

The image brightness obtained by the aforementioned sectioning image observation apparatus is in proportion to the translucent section area in the observation field on the rotation disk surface.

The width of the straight pattern of the translucent section of the rotation disk is decides as a value determined from a constant of the optical system for obtaining the sectioning effect as shown before. It is more effective to adopt a larger width for the shield section, because the plan resolution and the sectioning effect in the height direction are damaged by the filtration of non-focused light from adjacent translucent sections; however, in practice,

it is set to a certain value (for instance, in the
aforementioned example, translucent section: shield
section = 1:9) compromising the total light amount
contributing to the image formation. Thus, the line
5   width value of translucent section and shield section
is a fixed value, and the rotation disk permeability is
constant.

However, as represented by certain semiconductor
samples, there is a case of observing an upper and
10   lower images at the same time for a sample having a
predetermined height such as a multi-layered structure.
For the observation of such sample, sometimes it is
better to give the permeability in the observation
field on the rotation disk priority, and increase the
15   light amount contributing to the image, for securing
the image brightness.

On the other hand, in case of observation with
fluorescence, the increase of light source light amount
for securing the image brightness may increase the
20   irradiated light amount to the sample, resulting in
a premature fading. Similarly, for the sample in the
semiconductor filed, it can be considered that the
irradiation light alters the resist film, and damages
the sample in some cases.

25   Thus, concerning the application of high
sectioning effect of aforementioned sectioning image
observation apparatus to various kinds of sample, it is

considered difficult to apply to more various kinds of
sample observation, given the problem of lack of image
brightness due to low permeability of the rotation disk
especially in the fluorescent observation or the like.

5   It is evident that this restriction influences
prominently especially in eye observation.

FIG. 12 shows a schematic configuration applied to
the conventional confocal microscope of the sixth
embodiment, and the same symbol is affected to the same

10   part as FIG. 4.   In the configuration of FIG. 12, a
motor 16 and a transport stage 17 are added explicitly
to the configuration of FIG. 4, both the motor 16 and
the rotation disk 13 are mounted on the transport stage
17 and movable in a direction where the rotation disk

15   23 cross the optical axis.   The other configuration
being similar to that in FIG. 4, the detailed
description thereof will be omitted.

FIG. 13A and FIG. 13B show a rotation disk in the
sixth embodiment of the present invention. As shown in

20   FIG. 12A, the rotation disk 23 is divided into three
concentric areas 231, 232, 233 in the rotation radial
direction, and each areas has linearly formed
translucent section 23a and light shielding portion 23b
arranged alternately as shown in the enlarged view of

25   FIG. 13B.   The line widths of the shield portion 23b
are different respectively for three areas 231, 232,
233 mentioned above, and are for example:

231: 50 × L

232: 10 × L

233: 4 × L

in respect to the width L of the aforementioned

translucent section.

In this embodiment, 231, 232 and 232 of FIG. 3A

can be selected by moving the transport stage 17 for

the light incident position on the rotation disk 23,

namely the position of pattern projected to the sample

8 on the rotation disk 23. This is set so that the

observation field is contained within a specific area,

as shown by the dot line circle in FIG. 13A.

Consequently, the rotation disk permeability

in the field can be changed about 1 time, 5 times or

20 times by setting the transport stage 17.

Consequently, according to the sectioning image

observation apparatus of this embodiment, in case when

the height direction change of the sample 8 is small,

or when the irradiation amount to the sample is desired

to be restricted as in the fluorescent observation,

the permeability of the rotation disk 13 can be changed

by selecting the use portion of the rotation disk 23

different in shield section width, through the movement

of the transport stage 17.

This allows to set an appropriate sectioning

effect and image brightness in accordance with the

situation of the sample 8, and to perform the

sectioning image observation with appropriate
brightness for more various kinds of samples.

In addition, the rotation disk pattern per se is
a simple line pattern similarly as the prior art, that
will not increase the manufacturing cost, and can be
manufactured at a low cost.

(Seventh Embodiment)

Now, the seventh embodiment of the present
invention will be described.

In this case, as the confocal microscope to which
the seventh embodiment is applied is similar to that in
FIG. 12, FIG. 12 will be used.

FIG. 14 shows a rotation disk in a seventh
embodiment of the present invention. This embodiment
being pattern modification of the rotation disk of
the sixth embodiment, only pattern portion will be
described, and description of parts similar to the
sixth embodiment will be omitted.

In the rotation disk of this embodiment, in the
straight patterns 241 of the rotation disk as in
FIG. 14, the straight patterns 242 are disposed
orthogonal to the other portion in the portion where H
direction when the rotation disk 24 rotates and the
straight patterns become parallel as in FIG. 10.
Three areas different in shield section width are
disposed in the radial direction as in the sixth
embodiment. The adoption of such rotation disk pattern

limits the image uneven brightness at the position where the rotation direction (H direction) and the pattern direction become parallel, during the rotation disk rotation. The permeability of the rotation disk

5   can be changed by modifying the use point of the rotation disk as in the sixth embodiment, and this allows to modify the image brightness in accordance with the sample situation, by still even brightness in the field.

10   (Eighth Embodiment)

Now, the eighth embodiment of the present invention will be described.

In this case, as the confocal microscope to which the seventh embodiment is applied is similar to that in

15   FIG. 12, FIG. 12 will be used.

FIG. 15A shows a general view of the rotation disk 23 and FIG. 15B is a partial enlargement view of the rotation disk 25. As shown in FIG. 15A, the rotation disk 25 is divided in two areas 251 and 252 and,

20   as shown in FIG. 15B, straight patterns such as translucent section 251a and shield section 251b are arranged alternately.

The translucent sections 251a (or 252a), and shield sections 251b (or 252b) are arranged alternately

25   in the area 251 (or area 252), and the line width of the shield portion 251b (or 252b) is wider than the translucent sections 251a (or 252a) by 9:1.

Here, in order to dispose the area 252 disposed on the inner circumference side of the rotation disk 25, it can move in the arrow direction, by the transport stage 17 with manual or automatic control using

5 straight guide, ball screw, rack and pinion or the like connected to the motor 16.

Concerning the width L of translucent section, as in the case of pin hole, using the expression (1), suppose the projection magnification of the sample

10 image on the rotation disk be M, light wavelength λ and the aperture of the objective NA, and for instance in the area 251 of FIG. 15A, an objective 7 of magnification 100 times, NA = 0.9 are supposed and placed on the light path, the width L of the

15 translucent section 251a is set to the range of 30 to 60 μm by calculation with λ = 550 nm generally used.

On the other hand, in the area 252, suppose the magnification 20 times, NA = 0.4 for the objective 7, the width L of the translucent section 252a is set

20 in the range of 13.75 to 27.5 μm for the same wavelength λ.

The straight line direction in the observation field changes as the rotation disk 25 rotates; however, among the straight patterns of translucent sections

25 251a (or 252a) and shield sections 215b (or 252b), two shield areas 281a, 231b having a center angle of several degrees are disposed in the portion where the

pattern direction becomes parallel to the scanning
direction in the observation field, along a direction
orthogonal to the straight patterns of translucent
sections 251a (or 252a) and shield sections 215b

5   (or 252b).

Here, in the case when the sample image is desired
to be observed using the area 252 of FIG. 15A, the area
252 arranged on the inner circumference side of the
rotation disk 25 connected to the motor 16 can be

10 placed on the optical path (or in the observation
field) by moving in the arrow direction by the
transport stage 17 as shown in FIG. 12.

Besides, two shield areas 25a, 25b are arranged
as shown in FIG. 15A and 15B in the portion where the

15 direction of straight patterns of translucent sections
251a (or 252a) and shield sections 215b (or 252b)
become parallel to the scanning direction in the
observation field, and in these areas, observation
image is not formed, preventing uneven brightness from

20 appearing.

Thus, a good confocal image of the sample 8 can
be obtained only by moving the rotation disk 25,
without changing the rotation disk, as the optimal
pattern for the objective magnification and the number

25 of aperture can be selected from a plurality of areas
concentrically disposed on the rotation disk 25.

In addition, uneven brightness does not appear

in the observation image, because the rotation disk
pattern is as simple as arranging only translucence
portions and shield portions alternately. Besides, the
mask pattern can be created by the EB drawing machine,

5   by only scanning with electron beam in one direction,
at an extremely low cost, different from a precise and
complicated arrangement of a number of pin holes of the
rotation disk, as in the case of Nipkow rotation disk.

        (Ninth Embodiment)

10   Now, the ninth embodiment of the present invention
will be described.

        FIG. 16 illustrates the configuration of
the ninth embodiment of the present invention.
This embodiment is a pattern modification of the

15   rotation disk of the eighth embodiment, only pattern
portions will be described, and description of parts
similar to the eighth embodiment will be omitted.

        In the ninth embodiment also, the width of the
translucent section 261a (or 262a) is wider than the

20   shield section 261b (or 262b) and set to 9:1 for
instance. Besides the width L of the translucent
section 261a (or 262b) is decided by the aforementioned
expression (1).

        Among straight patterns of translucent sections

25   261a and shield sections 261b in the rotation disk of
this embodiment, there are provided two areas 263
having translucent section 263a, shield section 263b

disposing straight patterns and placed orthogonal to
the straight patterns of translucent sections 261a and
shield sections 261b in the portion where the straight
patterns become parallel to the rotation disk scanning
5   direction when the rotation disk 24 rotates. These two
area 263 are disposed symmetric to the rotation disk
center. Two areas 263 described above are formed by
changing the length of respective straight pattern
sequentially from the rotation disk periphery, and the
10   center angle θ is decided by the reduction degree of
uneven brightness, width of the shield section 261b and
translucent section 261b, and distance R between
the observation field and the rotation disk 26 rotation
center. For instance, in the two areas 263, when the
15   translucent section is 20 μm, the shield section
180 μm, and distance R 30 mm, in order to reduce
the uneven brightness to 1 % or less, θ is about
10 degrees.

      In case where a low magnification objective
20   (and low NA objective) is used, as the width of the
translucent section 262a reduces, for instance, in two
areas arranged symmetrical to the rotation center,
suppose the translucent section be 6 μm and the shield
section 54 μm, the center angle $\theta 2$ can be determined
25   from FIG. 11.

      Similarly to the eighth embodiment, if the sample
image is desired to be observed using the inner

circumference side area 4 of the rotation disk 26, objective lens 7 different in magnification and number of aperture can be used only by moving the rotation disk 26, without changing the rotation disk 26, by moving the rotation disk 26 connected to the motor 16 in the arrow direction as shown in FIG. 12.

In addition, a sectioning image can be obtained without making uneven brightness, by forming area 264a and area 264b, for the portion in parallel with the rotation disk scanning direction, among straight patterns arranging translucent section 261a (or 262b) and shield section 261b (or 262b) alternately.

Further, patterns can be formed on the rotation disk at a low cost, because there are nothing but two straight line directions, even though this rotation disk is divided into four in the circumferential direction.

(Tenth Embodiment)

Now, the tenth embodiment of the present invention will be described.

FIG. 17 illustrates the configuration of the tenth embodiment of the present invention. This embodiment is a pattern modification of the rotation disk of the eighth embodiment, only pattern portions will be described, and description of parts similar to the eighth embodiment will be omitted.

The rotation disk 27 of this embodiment is divided

by 120 degrees in the circumferential direction of the
rotation disk 27 so that there is no potion where the
straight patterns becomes parallel to the rotation disk
scanning direction in the observation field when the
5   rotation disk 24 rotates, among straight patterns of
the rotation disk as shown in FIG. 17.

     Straight pattern translucent section 272a, shield
section 272b can be disposed on the light path in the
area 6, allowing to respond to a low magnification
10   objective.

     Similarly to the eighth embodiment, in the case
when the sample image is desired to be observed using
the area 6 on the inner circumference side of the
rotation disk 27, objectives 7 different in magnifica-
15   tion or number of aperture can be adopted, only by
moving the rotation disk 27, without exchanging the
rotation disk 27, by moving the rotation disk 27
connected to the motor 16 in the arrow direction as
shown in FIG. 12.

20   The sectioning image can be obtained without
producing uneven brightness, because there is no
straight pattern becoming in parallel with the rotation
disk scanning direction in the observation field of
the rotation disk 27. Further, in this embodiment,
25   patterns can be prepare precisely at a low cost,
because, there are nothing but straight line patterns.

(Eleventh Embodiment)

FIG. 18 illustrates the configuration of the eleventh embodiment of the present invention. This embodiment being a pattern modification of the rotation disk of the eighth embodiment, only pattern portions will be described, and description of parts similar to the eighth embodiment will be omitted.

For the rotation disk of this embodiment, there are provided areas 283 (or areas 284) having a plurality of straight patterns constant in diameter X1 (or X2) of translucent section 283a (or 284a) placed orthogonal to the direction of the straight patterns of translucent sections 281a (or 282a) and shield sections 281b (or 282b) in the portion where the straight patterns of translucent sections 501a (or 502a), shield sections 281b (or 282b) of the rotation disk 28 become parallel to the scanning direction by the rotation of the rotation disk as shown in FIG. 18.

For instance, FIG. 11 shows the result of calculation of the angle θ, supposing that, in the area 7, translucent section width be 6, μm, shield section width 54 μm, distance from rotation disk 28 center R and uneven brightness 1%. Longer is the distance R, smaller is θ, and in FIG. 18, given X1 = R $\times$ sinθ for the width X1, it becomes substantially a constant value, allowing to make the uneven brightness in the observation field to a fixed

value or less, thereby to perform an satisfactory
sample observation.

Similarly, the width of X2 of the area 8 can be
determined from the proportion of dimension width to
5   the translucent section 282a and shield section 282b.

Similarly to the eighth embodiment, when the
sample image is desired to be observed using the area 8
on the inner circumference side of the rotation disk
28, objectives 7 different in magnification or number
10 of aperture can be accommodated, only by moving the
rotation disk 28, without exchanging the rotation disk
28, by moving the rotation disk 28 connected to the
motor 16 in the arrow direction.

In addition, the formation of straight patterns
15 such as the area 283 allows to obtained the sectioning
image without producing uneven brightness, Further, in
this embodiment, patterns can be prepare precisely at
a low cost, because, there are nothing but straight
line patterns.

20   In the respective aforementioned embodiments,
examples wherein different directions of straight
line patterns are disposed at right angles each other
were shown; however, it is unnecessary to be always
90 degrees. The angle in respect to the rotation disk
25 rotation direction may be any degrees provided that
being larger than θ which is a degree calculated by
the uneven brightness.

(Twelfth Embodiment)

Now, the twelfth embodiment of the present invention will be described.

In this case, as the confocal microscope to which the seventh embodiment is applied is similar to that in FIG. 12, FIG. 12 will be used. In addition, disk pattern of this embodiment being similar to that in FIG. 18, the illustration and description thereof be omitted.

FIG. 19 is a partial enlargement view of the pattern section of the rotation disk 28 in FIG. 18.

Now, the rotation disk pattern will be described in detail. Different direction areas where tow patters are orthogonal to the other portion are provide in a portion where the direction of straight patterns of the translucent section 281a (or 282a) and shield section 281b (or 282b) become parallel to the scanning direction in the observation field. The reduction degree of contrast stripe can be decided by the widths X1, X2 of theses different direction areas. Suppose a contrast stripe in a certain rayon on the rotation disk. For the calculation convenience, suppose the portion where patterns go straight {cross at right angles} be fan-shaped, and the half angle from the center thereof θ.

When the width of the translucent section is L and a width of the translucent section and shield

section is W, from r = R when the rotation disk make half revolution, the ratio of the maximum and the minimum brightness of the reflected light in the range of r = R + W is the contrast ratio.

5   Suppose the rotation disk rotation angle be ϕ, the range of $\phi = -\theta$ to θ is different in slit direction by 90 degrees.

The slit image projected on the rotation disk when a slit is projected on a sample, reflected and returned

10   again to the rotation disk is not rectangular influence by the NA of the objective lens. Suppose a sinc function having 0 point at L, approximately. When the rotation angle of the rotation disk is ϕ, the reflected light amount V (r, ϕ) passing through the

15   rotation disk is:

$$V(r,\phi) = \begin{cases} \sin c\left(\dfrac{x(r,\phi)}{L} - \dfrac{L}{2}\right) & x(r,\phi) \leq L \\ 0 & L < x(r,\phi) \leq W \end{cases} \quad \cdots (4)$$

Here,

$$x(r,\phi) = r\sin\phi - L\operatorname{int}\left(\dfrac{r\sin\phi}{L}\right) \qquad -\theta < \phi < \theta \quad \cdots (5)$$

20

$$x(r,\phi) = r\cos\phi - L\operatorname{int}\left(\dfrac{r\cos\phi}{L}\right) \qquad \text{otherwise}$$

However, provided that int(x) is a function expression the integer portion of x.

Therefore, the light amount S (r) of the position

25   of which distance from the center is r, is determined by integrating V by a half revolution:

$$S(r) = \int_{\frac{\pi}{2}}^{-\frac{\pi}{2}} V(r,\phi)d\phi \qquad \cdots (6)$$

In the calculation of the expression (6), ϕ is $-\pi/2$ to $\pi/2$ integrated; however, in reality, the rotation disk being symmetrical to x axis y axis,

5   a range of ϕ = 0 to $\pi/2$ corresponding to a 1/4 revolution is sufficient. This is calculated from r = R to R + W, and the ratio of maximum value and minimum value thereof is the contrast ratio of the moment when the portion whose slit is vertical has an angle of θ.

10   Suppose the contrast ratio be Iratio (θ),

$$I_{ratio}(\theta) = \frac{\max\left(S(r)_{r=R}^{r=R+W}\right)}{\min\left(S(r)_{r=R}^{r=R+W}\right)} \qquad \cdots (7)$$

The variation thereof is determined for the range of θ = 0 to $\pi/4$ (45 degrees) and the variation of

15   contrast ratio for respective slit width and distance R from the center according to θ is calculated for judging how many degrees will be convenient as θ. If the angle θ is converted into the width X of the different direction area:

20
$$X = R\sin\theta \qquad \cdots (8)$$

FIG. 21 shows the relationship between the contrast ratio and the different direction area width X. It is a contrast ratio at the position

25   R = 25 mm and R = 40 mm with the translucent section slit width L = 30 μm, W = 300 μm. From FIG. 21, it is understood that curbs agree each other event at R = 25 mm, 40 mm. In short, the variation of contrast

ratio is decided by the different direction area width

X independently of R provided that L and R are same.

Larger is X, smaller is the contrast ratio; however,

exceeding once a fixed value, it varies scarcely.

5   It is around X = 15 mm in case of FIG. 21.

Therefore, if the slit width L of the translucent

section is 30 μm, and W is 300 μm for 232 of FIG. 19,

X2 = 10 mm may be set.

Next, suppose both L and W are larger. FIG. 22

10   shows the calculation results for L = 60 μm,

W = 600 μm. FIG. 22 shows a prominent relief around

X = 20 mm; however, the contrast ratio varies scarcely

around 20 to 25. This corresponds to a position about

two times compared to FIG. 21. In other words, if L:W

15   does not change, it is understood that it is enough

to double the value of X, when W has doubled.

Suppose L = 60 μm, and W = 600 μm for 231 of FIG. 19,

X1 = 20 mm may be set.

The foregoing shows that, among the translucent

20   section slit width, cyclic width L of translucent

section and shield section, and different direction

area width X, there is a law saying "suppose the duty

ratio L/W be constant, X is proportional to W".

However, an upper limit is applied to the

25   magnitude of X, by the distance R from the rotation

disk center. The examination of FIG. 20 shows that

when the angle θ is equal or superior to 45 degrees,

then, the pattern area in the orthogonal direction becomes narrower. In short, the maximum value of X is:

$$X \le R \sin \frac{\pi}{4} \qquad \cdots (9)$$

As X is proportional to W, if a pattern responding to a plurality of objective is desired with L:W constant, the translucent section larger in the slit width L should be disposed outside the circle as shown in FIG. 18.

For the rotation disk of this time, as the slit width is different for inside and outside two bands as shown in FIG. 18, it will be enough to dispose the smaller slit width inside, and the lager slit width outside.

As mentioned above, it was made possible to observe a good quality confocal image, even when observed changing the area, because it was made possible to select a pattern matched with the objective magnification or number of apertures from a plurality of areas arranged concentrically on the rotation disk 28, and at the same time, it was made possible to decide appropriately the width X of the different direction area orthogonal to the pattern for avoiding contrast strips provided in each area by the pattern cycle W. Further, if the translucent section slit width L and its cycle W are constant, it is enough to design so that said width X of the different direction area is in proportion to W, making unnecessary to

create a trial pattern to decide its the different

direction area, and reducing time and cost.

(Thirteenth Embodiment)

FIG. 23A and FIG. 23B illustrate the configuration

5   of the thirteenth embodiment of the present invention.

This embodiment being a pattern modification of the

rotation disk of the eleventh embodiment, only pattern

portions will be described, and description of parts

similar to the eleventh embodiment will be omitted.

10   For the rotation disk of this embodiment, a

rotation disk 29 is divided into two concentric areas

as shown in FIG. 23A, and the translucent section slit

width L is identical for outside areas 291, 293 and

inside areas 292, 294, and the cycle W1 of outside

15   translucent section and shield section and the inside

cycle W2 are made different in width as shown in

FIG. 23B. A different direction area 603 is disposed

outside 2 × 1 in width, a different direction area 604

is disposed inside with its width 2 × 2, and patterns

20   of this portion are orthogonal to the other portion.

According to this embodiment, in the case when the

sample image is desired to be observed using the area 8

on the inner circumference side of the rotation disk

29, different patterns can be selected, only by moving

25   the rotation disk 29, without exchanging the rotation

disk 29, by moving the rotation disk 29 connected to

the motor 16 in the arrow direction. Different from

the fourteenth embodiment, the slit width is of the same value inside and outside, but the cycle thereof is different.

When a sample is observed, sometimes the brightness takes priority over the Z resolution, by reducing the confocal effect. As it is known that higher is W/L, better is the confocal effect (Z resolution), in a case as the forgoing, the observation can be performed by simply changing the brightness and confocal effect be executing the aforementioned changeover, by changing the ratio of L and W inside and outside as in this embodiment.

In this embodiment, the slit width L is identical, and only the cycle W is different for two areas 291, 292. The relationship of width X of the different direction area for such case will be shown.

Suppose the translucent section slit width L = 30 μm, its cycle W1 = 150 μm. As in the eleventh embodiment, FIG. 24 shows the calculation results of the relationship between the contrast ratio and the different direction area width X. From FIG. 24, it is understood that the contrast ratio varies little approximately when X = 5 mm is exceeded. Compared to FIG. 21 where W is double as W = 300 μm for the same L, the contrast ratio becomes substantially a fixed value at the position where X is double. In order to confirm this, FIG. 25 shows the calculation results

of the contrast ratio with an extremely large W as
W = 1200 μm for the same L = 30 μm. Here, the
contrast ratio varies scarcely around X = 40 to 60 mm,
and it is understood that the value of X is four times
higher compared to W = 300 μm of FIG. 21, as expected.

In short, "a width X of the different direction
area making the contrast ratio a fixed value or below,
regardless of 'L/W, is proportional to the pattern
cycle W".

In addition, similarly to the eleventh embodiment,
given the relationship of the expression (9) exists
between the distance R from the rotation disk center
and X, it is necessary to dispose the pattern with
larger W outside. In short, "when a plurality of
patterns are to be disposed on the rotation disk, it is
preferable to increase the distance R from the rotation
disk center, and if it is impossible, those of larger W
will be arranged outside".

Therefore, in case of this embodiment, for
instance, it can be set as follows:

Inside: L = 30 μm, W = 150 μm

Outside: L = 30 μm, W = 300 μm.

As mentioned above, it was made possible to
observe images with different confocal effect and
brightness, without changing the rotation disk,
because it was made possible to select a pattern of
the same slit width L and different cycle width L from

a plurality of areas arranged concentrically on the rotation disk 29, and at the same time, it was made possible to observe a good quality confocal image, even when observed changing the area, because it was made

5 possible to decide appropriately the width X of the different direction area orthogonal to the pattern for avoiding contrast strips provided in each area by the pattern cycle W. Further, if the translucent section slit width L and its cycle W are constant, it is enough

10 to design so that said width X of the different direction area is in proportion to W, making unnecessary to create a trial pattern to decide its the different direction area, and reducing time and cost.

In the embodiment, it was proposed to dispose two

15 areas in the inner circumference side and the outer circumference side of the rotation disk 29: however, if the area is contained within the observation field, three or more pattern areas corresponding to respective objective 7, or different in Z resolution, may be

20 disposed concentrically on the rotation disk 29.

(Fourteenth embodiment)

Now the fourteenth embodiment of the present invention will be described.

FIG. 26 shows a schematic configuration applied to

25 the confocal microscope according to the fourteenth embodiment, and the same symbol is affected to the same portion as FIG. 4. In the configuration of FIG. 12,

a motor 16 is added explicitly to the configuration
of FIG. 4, and the rotation disk is constituted slant
to the optical axis by a predetermined angle θ. The
other configuration being similar to that in FIG. 4,

5   the detailed description thereof will be omitted.

The rotation disk 13 is slant to the plane
vertical to the optical axis by an angle θ, connected
to the motor 16 through a rotation shaft 12, and
rotates at a fixed rotation speed. The pattern of

10   the rotation disk 12 is usable by any rotation disk
of respective embodiment as mentioned above, the
description and illustration of the pattern will be
omitted.

In the configuration of FIG. 26, light reflected

15   from the sample 8 passes through the objective 7,
becomes a straight polarized light orthogonal to the
incidence at the 1/4 wavelength plate 6, and forms
an image of the sample 8 on the rotation disk 13
through the first imaging lens 5. Among formed images,

20   most of confocal component passes through the
translucent section on the rotation disk 13, but cannot
pass if not focused. Most of light of non-confocal
component is absorbed by the shield section, but
partially reflected. Given the permeability not 100%,

25   light of translucence portion also is reflected
partially. The component having passed through the
translucence portion of the rotation disk 13 passes

further through the PBS 3 and confocal component in the sample image is imaged by the CCD camera through the second imaging lens 9. On the other hand, if the reflected light passes again through the first imaging
5   lens 5, objective 7 and passes through the translucent section of the rotation disk 13, reflected by the sample or others, it may possibly create flare deteriorating the image contrast.

FIG. 27 is a partial enlargement view of the
10 rotation disk and the first objective.

The rotation disk 13 is slant to the plane vertical to the optical axis by an angle θ, and suppose the magnification of sample image projected on the rotation disk 13 be M, and the diameter of the
15 observation field on the rotation disk 13 R; the number of apertures of the objective 7 be NA. First, the image projected on the optical axis in the center of the field. As sin of the maximum incident angle ϕ at this point on the rotation disk is the quotient of the
20 objective NA by the magnification M, suppose the angle be small,

$$\psi = NA/M$$

As the rotation disk is slant to the plane vertical to the optical axis by θ, light of said
25 maximum incident angle ϕ is incident to the axis to the rotation disk by

$$\theta \pm \psi = \theta \pm NA/M$$

when this light is partially reflected, it should be

$$NA/M < \theta \pm NA/M \qquad \cdots (5)$$

so that it does not enter the objective.

As all symbols are positive, eventually

$$\theta > 2NA/M \qquad \cdots (6)$$

will be satisfied.

These are discussions about the central point of the field of view, the angle of the light to the rotation disk from the sample attains its maximum at the point at the edge of the observation field as the right side line of FIG. 27. In this case, it is necessary to add an angle ϕ between the optical path and a main optical line passing the point in the edge of the observation field to (5). Eventually, the rotation disk inclination θ condition for preventing light from the sample, if reflected from the rotation disk 13, from entering the objective 7 again will be:

$$\theta > \psi + 2NA/M \qquad \cdots (2)$$

These consider only the case of light from the sample, and do not refer to the flare in case of reflection of light from the light source by the rotation disk. Ordinary microscopes are designed so that the light from the light source enters, in a way to illuminate the observation filed with an even brightness, and satisfy the objective NA. The expression (2) is satisfied as it is for the light from the light source,

because this condition is absolutely identical to the one for the light from the sample to form the image in a way to satisfy NA with an even brightness in the field of view of the rotation disk.

According to the expression (2), the larger the better is θ; however, it is necessary to be included within the depth of focus, in the observation field projected on the rotation disk, because it is focused on different height, when the focal plan of the sample is slant in respect to the rotation disk plan. The sample plan depth of focus zd is given approximately by the following expression with the objective NA and the wavelength λ.

$$z_d = \frac{0.9\lambda}{NA^2}$$

The depth of focus z'd of the sample image projected on the rotation disk being multiplied by M^2:

$$z'_d = \frac{0.9M^2\lambda}{NA^2} \qquad \cdots \ (7)$$

It is necessary to be included within the focal depth range of the expression (7), in the observation field of the sample image projected on the rotation disk slant by the angle θ. Suppose the diameter (number of fields) on the rotation disk 13 be R, the condition of θ to be determined is:

$$\tan\theta < \frac{z'_d}{R} = \frac{0.9M^2\lambda}{NA^2 R} \qquad \cdots \ (8)$$

Suppose θ be small, the constant about 1,

approximately, the condition:

$$\theta < \frac{M^2 \lambda}{NA^2 R} \qquad \cdots (3)$$

will be satisfied.

As an example, suppose a case where the objective is M = 50 [times], NA = 0.9, number of field R = 11 [mm]. Suppose the light wavelength λ = 0.55 [μm]. As ϕ is given by:

$$\phi = \frac{\dfrac{R}{2}}{L} = \frac{5.5}{180} = 0.0306 [rad]$$

when the depth of focus of the first objective is L, and L = 180 [mm], from this and the expression (2)

$\theta > 0.067$[rad] = 3.8°

and, from the expression (3)

$\theta < 0.154$[rad] = 8.8°

therefore, it will be enough to set θ in the range of 3.8° < θ < 8.8°

As mentioned above, a confocal image free from focus inclination or flare, by deciding the inclination angle θ of rotation disk 13, in correspondence to the objective magnification, number of aperture, and number of field can be obtained.

(Fifteenth embodiment)

Now the fifteenth embodiment of the present invention will be described.

FIG. 28 shows the configuration of the fifteenth embodiment. The same symbols are affected to the same

portions as FIG. 14.

The rotation disk 13 is slant to the plane vertical to the optical axis by an angle θ, connected to the motor 16 through a rotation shaft 12, and rotates at a fixed rotation speed. As rotation disk 13, for instance, the rotation disk of the six embodiment and thereafter can be applied. The motor 16 can move the transport stage 17 in the arrow direction, keeping the angle θ, under the manual or automatic control using linear guide, ball screw, rack and pinion or others.

Now the function of this embodiment will be described. Here, as for the rotation disk, the disk 28 shown in FIG. 18 will be used.

When 100 times, NA = 0.95 are adopted for the objective 7, the rotation disk is turned by the transport stage 17 connected to the motor 16, so that areas 281, 283 of the rotation disk 13 are positioned on the optical path. The function up to the imaging by the light from the light source is identical to the fourteenth embodiment. Next, when the objective 7 is changed to 30 times, NA = 0.5, the areas 282, 283 disposed on the inner circumference side of the rotation disk 28 are moved by the transport stage 17 connected to the motor 16 in the arrow direction to place them on the optical path (or observation field).

Now, the rotation disk inclination at this time

will be examined. The number of fields, depth of focus
of the first objective, and light wavelength are the
same as the fourteenth embodiment.

When the objective lens is 100 times, NA = 0.95,
5   from expressions (2) and (3):

$$2.8° < \theta < 31.7°$$

When the objective lens is 20 times, NA = 0.4, from
expressions (2) and (3):

$$4.0° < \theta < 7.2°$$

10   Consequently, it is enough to decide the angle θ, in
a way to satisfy the condition for the objective of
20 times.

As mentioned above, also in the case where a
plurality of patterns are provided, a good contrast
15   sectioning image can be observed, even when the
objective lens setting to the rotation disk inclination
condition, from the lens characteristics used for
respective pattern, is changed.

In this embodiment, two areas are disposed on the
20   inner circumference side and the outer circumference
side of the rotation disk 13: however, if the area is
contained within the observation field, three or more
pattern areas corresponding to respective objective,
may be disposed concentrically on the rotation disk 13.

25   In the aforementioned embodiments, examples
satisfying both expressions (2) and (3) simultaneously
were shown; however, they are not always satisfied

simultaneously. For instance, even when an objective
lens of 20 times, NA = 0.4, if the observation field
is large. For instance the number of field R = 25,
suppose the other conditions be identical, the
expression (2) will be:

$$\theta > 6.3° \qquad\qquad \cdots (2)'$$

under the conditions of the expression (3):

$$\theta < 3.2° \qquad\qquad \cdots (3)'$$

and it becomes impossible to satisfy (2)' and (3)'
simultaneously. In such a case, it will be set to
satisfy only the condition (3)' to be enter the depth
of focus, without considering the flare reduction
condition (2)'; while the flare will be reduced by
another means such as enhancement of optical system
antireflective coat, improving the polarization rate of
the optical system for polarization.

(Sixteenth embodiment)

Now the sixteenth embodiment of the present
invention will be described. Different from the first
to thirteenth embodiments, this embodiment uses a micro
mirror in place of rotation disk.

FIG. 29 illustrates the configuration of the
sixteenth embodiment, and the same symbol is affected
to the same portion as FIG. 4, and the description
thereof will be omitted.

As for the micro mirror array 32 applied to the
present invention, a number of mirror, each several μm

to several tens of μm are arranged two-dimensionally
as shown in FIG. 30A, and individual mirror
is supported by two bars as shown in FIG. 30B.
A different electrode is attached respectively to the
5   individual mirror, and three states, faced to the front
(2), inclined oppositely each other (1), (3), can be
changed over depending on the voltage applied to the
electrode as shown in FIG. 30C.

Light emitted from the light source 1 passes the
10   optical lens 2, becomes a straight line polarized light
containing only a certain polarized light at the
deflecting plate 15, and enters the PBS 3. The PBS 3
reflects the polarized light in the direction passing
through the deflecting plate, and permeates the
15   polarized light in a direction perpendicular to this.
Light reflected by the PBS 3 is reflected by a first
mirror 31 and enters the micro mirror array 32 with
an incident angle of 45 degrees. In the micro mirror
array 32, light incident to the micro mirror array 32
20   faced to the front of FIG. 30C(2) is reflected in the
direction of the second mirror 33, and light incident
to the micro mirror array faced to the direction (1) or
(3) of FIG. 30C is directed to the other direction.
Light directed in the direction of the second mirror 33
25   is reflected in the direction of the first imaging lens
5 by the second mirror 33, passes through the first
imaging lens 5, becomes a circular polarized light at

the 1/4 wavelength plate 6, is imaged by the objective

7 and enters the sample 8.

On the other hand, light reflected from the sample

8 passes through the objective 7, becomes a straight

5   polarized light orthogonal to the incidence at the 1/4

wavelength plate 6, I reflected by the first mirror 7

in the direction of the micro mirror array 32 and forms

a sample image on the mirror array through the first

imaging lens 5. In the micro mirror array 32,

10   similarly as before, light incident to the micro mirror

array 32 faced to the front of FIG. 30C(2) is reflected

in the direction of the first mirror 31, and light

incident to the micro mirror array faced to the

direction (1) or (3) of FIG. 30C is directed to the

15   other direction. At this time, as confocal image is

formed on the portion faced to the front of FIG. 30C

(2) and non-focused portion on the other micro mirror,

only focused portion proceeds in the direction of the

first mirror 31.

20   The focused component is reflected by the first

mirror 31, passes through the PBS 3 and the sample

image is formed on the CCD camera 13 through the second

imaging lens 12.

Now, the actual shooting operation will be

25   described.

The size of individual mirror of the micro mirror

array 32 is supposed to be 10 μm $\times$ 10 μm. As an

example, suppose the objective lens be 10 times and NA = 0.3. At this time, the appropriate slit width at the micro mirror array 32 position is about 10 μm from the expression (1). A period of each slit assumed to be 50 μm.

For imaging, first, a computer 34 sends a command to a driver 35, to direct the micro mirror array 32 to respective mirror as shown in FIG. 31A. In FIG. 31A and FIG. 31B, white portions are mirrors faced to the front as in FIG. 30C(2), while black portions, inclined as (3) in FIG. 30C, are directed to the second mirror 33. As the illumination light is irradiated to the sample only when the micro mirror faces to the front, as mentioned before, an image of slit light juxtaposition is projected on the sample. In this state, the computer 34 sends a command to open the shutter of the CCD camera 10, to start the exposure by the CCD camera 10.

During the exposure with the shutter open, the micro mirror pattern is shifted as follows.

First, from the state of FIG. 31A, the computer 34 sends a command to the driver 35 so that the slit light moves in Y direction of FIG. 31A by one line, or so that the micro mirror array pattern becomes as shown in FIG. 31B. If this were repeated 3 more times, the sample would have been scanned evenly; however, as it is, similarly as the slit scanning, the resolution in X

direction results in being inferior to the resolution
in Y direction, provoking an anisotropy. In a way to
cancel, continuously, a pattern inclined by 45 degrees
in respect to X as in FIG. 32A is moved in the S
direction of FIG. 32A in the same manner, for scanning.
Further, the scanning is performed similarly for the
pattern of 90 degrees as in FIG. 32B or of 135 degrees
as in FIG. 32C, the shutter is closed to finish the
exposure, and the taken image is transferred to the
computer 34 to display the image on the monitor 11.
The aforementioned operation allows to obtain a
confocal image of less anisotropy.

Now, the case of objective exchange will be
examined. When the objective is 50 times, NA = 0.8,
the slit width being about 20 μm from the expression
(1), one slit corresponds to two lines of micro mirror,
and to obtain an slit interval of 100 μm with the same
ratio to the slit width (duty ratio 1:5) as for the
10 times objective, it will be enough to adopt a
pattern as shown in FIG. 32D. Besides, as mentioned
before, a confocal image can be obtained by moving
changing the pattern direction. For convenience,
12 X 12 micro mirror array is illustrated in the
drawing; however, in reality, 500 X 500 or more
mirrors are arranged, therefore, the confocal image can
be obtained similarly for larger slits width, for
instance, even for a slit width of 40 μm or so of the

of a 100 times, NA = 0.9 objective or the like.

Though the angle is change by 45 degrees in this
embodiment, it is not necessarily to limit to this
angle. 90 degrees or 30 degrees or 5 degrees will
5   be adopted. Smaller is the angle, smaller is the
anisotropy different in resolution according to the
direction, it takes a long time per screen. Though
the slit width to slit interval ratio is set to 1:5,
it goes without saying that this value may be set
10   arbitrarily in order to change the brightness or the Z
direction resolution.

(Seventeenth embodiment)

FIG. 33 shows a schematic configuration of the
present invention applied to the confocal microscope,
15   and the same symbol is affected to the same portion as
FIG. 12.

In this case, a condenser lens 2, an excitation
filter 36, and a dichroic mirror 37 are arranged on
a light path of the light emitted from a light source 1
20   such as mercury light source or others, and a rotation
disk 13, a first imaging lens 5, and a sample 8 through
an objective 7 are arranged on the reflected light path
of the dichroic mirror 37. In addition, a CCD camera
10 is arranged through an absorbing filter 38 and a
25   second imaging lens 9 on the filtered light path of
the dichroic mirror 37 of the light emitted from the
sample 8. A monitor 11 is connected to the image

output terminal of this CCD camera 10 for displaying the image taken by the CCD camera.

Here, similarly as mentioned for FIG. 5A and FIG. 5B, for the rotation disk 13, respective patterns of linearly formed translucent sections 13a and linearly formed shield sections 13b are arranged alternately, and at the same time, the width dimension of the straight shield section 13b is larger than the width dimension of the straight translucent section 13a, and set for instance to 1:9.

The excitation filter 36 has such translucence characteristics that the permeability attains the maximum in a wavelength band shorter than the fluorescence wavelength a as shown in FIG. 34, filters selectively a light of a predetermined frequency exciting the fluorescence, and shields light of the other wavelength. The dichroic mirror 37 has such reflection characteristics that the reflectivity attains the maximum in a wavelength band shorter than the fluorescence wavelength a as shown in FIG. 35A, reflects the light of the wavelength having passed through the excitation filter 36, has such translucence characteristics that the permeability attains the maximum in a wavelength band including the fluorescence wavelength a as shown in FIG. 35A and FIG. 35B, and filters the fluorescence wavelength emitted from the sample 8. In addition, the absorbing filter 38 has

such translucence characteristics that the permeability attains the maximum in a wavelength band including the fluorescence wavelength as shown in FIG. 35B, shields the excitation wavelength having passed through the excitation filter 36 and filters the fluorescence wavelength.

The wavelength characteristics of these excitation filter 36, dichroic mirror 37 and absorbing filter 38 are different according to the fluorescent pigment to be used and, for example, in case of observing FITC, given the maximum excitation wavelength 490 nm, the maximum fluorescence wavelength 520 nm, a wavelength of 460 to 490 nm is used as wavelength for filtering the excitation filter 36 and as wavelength reflected by the dichroic mirror 37, and a wavelength of 510 nm is used as wavelength for filtering the absorbing filter 38.

In such configuration, light emitted from the light source 1 passes through the condenser lens 2, and light of fluorescence exciting wavelength is selected by the excitation filter 36, and introduced to the dichroic mirror 37. The dichroic mirror 37 reflects the light of the wavelength having passed through the excitation filter 36, and the light reflected by the dichroic mirror 37 enters the rotation disk 13 turning at a fixed speed.

Then the light having passed through the straight translucent section 13 of this rotation disk 13 passes

through the first imaging lens 5, forms an image by the objective 7 and enters the sample 8. This incident light generates fluorescence from the sample 8.

Fluorescence generated from the sample 8 and reflection light passé through the objective 7, and form the sample image on the rotation disk 13 through the first imaging lens 5.

In this case, a focused portion of the sample 8 is projected in line on the rotation disk 13 in the form of product of the projected line and the sample image, and can pass the translucent section 13a of rotation disk 13; however, most of non-confocal image cannot pass through the rotation disk 16, because its image projected on the rotation disk 13 is also non-focused. As it is, the sample image and the pattern image are simply superposed; however, according to the rotation of the rotation disk 13, the pattern image is moved (scanned) on the sample image changing the direction, averaging them and canceling the line image, allowing to obtain a confocal image.

Then, fluorescence and reflection light having passed trough the translucent section 13a of rotation disk 13 enter the dichroic mirror 37 and as dichroic mirror 37 filters the fluorescence wavelength and the absorbing filter 38 also filters light of fluorescence wavelength, only the fluorescence is formed as a sample fluorescent image on the CCD camera through the second

imaging lens 9 and can be observed on the monitor 11.

Therefore, in this way also, effects similar to the aforementioned first embodiment can be expected.

Note that the rotation disk used for this seventeenth embodiment is an example, and it can also be applied to the rotation disk described for respective embodiment mentioned above.

The present invention is not limited to the aforementioned embodiment, but can be modified variously without departing from the subject matter of the invention.

For example, in the fourth and fifth embodiments among respective embodiments mentioned above, the straight pattern area of other translucent section and shield section is formed in the direction orthogonal to the straight patterns of translucent section and shield section in both of them, it in not always required to be orthogonal.

In addition, though in the aforementioned embodiment, images taken by the CCD camera 10 are displayed on the monitor 11, they may be eye observed in place of CCD camera 10. Besides, a half mirror can be disposed on this side of the second imaging lens 9 and an objective on the split optical path, allowing both eye observation and CCD, or a full reflection mirror is mounted detachably to switch over both observation methods.

Further, though in the aforementioned embodiment, the width ratio of straight translucent section and shield section is set to 1:9, this ratio may be set to a larger or smaller value; when it is set to 1:3 or so, the image is brighter, but contains more non-confocal component. If it is set to 1:50 or 1:100, non-confocal component exists hardly, allowing to obtain a sectioning image constituted uniquely of confocal images can be obtained.

Still further, though in this embodiment, there is shown an embodiment where two areas are disposed on the inner circumference side and the outer circumference side of the rotation disk: however, the observation is sometimes performed by connecting an objective 7 different in magnification and number of aperture to a not shown revolver, if the area is contained within the observation field, three or more pattern areas corresponding to respective objective 7, may be disposed concentrically on the rotation disk.

Moreover, though not mentioned in the aforementioned embodiment, the three-dimensional observation can be realized by putting the sample on a Z stage, and capturing images by changing the distance between the sample 8 and the objective 7.

As mentioned before, according to the present invention, a pattern formation member applied to a sectioning image observation apparatus allowing to

observe stably a quality image without making the observed image brightness uneven, and a sectioning image observation apparatus can be supplied.

As the foregoing, the present invention is
5   appropriate for a pattern formation member applied to a sectioning image observation apparatus for observing/ measuring sample microstructure or three-dimensional shape using light and a sectioning image observation apparatus.

10   Additional advantages and modifications will readily occur to those skilled in the art.   Therefore, the invention in its broader aspects is not limited to the specific details and representative embodiments shown and described herein.   Accordingly, various
15   modifications may be made without departing from the spirit or scope of the general inventive concept as defined by the appended claims and their equivalents.